8th Asia-Pacific Conference on Plasma Physics, 3-8 Nov, 2024 at Malacca

Investigation and wave number analysis of meso-scale structures formed in plasma turbulence

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Meso-scale structures such as streamers and zonal flows are formed in plasma turbulence by nonlinear interaction between microscopic drift waves in fusion plasmas. Since these structures significantly influence the plasma radial transport, to study the formation of meso-scale structures is important in plasma physics and fusion reactors.

By using the linear plasma device in Kyushu University, our group succeeded in finding the streamer structure and its mediator mode for the first time [1]. In the previous studies, our group clarified the cross-sectional structures of the streamer, its mediator mode, and carrier drift waves [2]. Several Langmuir probes arranged in the axial direction including the 64-channel poloidal probe array, and bi-spectral and bi-phase analyses were used to observe the three-dimensional phase structures. The results were well compared with theoretical [3] and numerical [4] works. While the streamer structure and carrier drift waves were radially elongated, the mediator mode had a node in the radial direction. Additionally, the axial dimensional research revealed that while the carrier drift waves had an axial mode number one (propagation direction from the end to the source), the streamer and mediator were revealed to have an axial mode number zero [5].

However, in plasma turbulence, there might be several modes with different poloidal mode numbers but with similar frequencies. To distinguish the cross-sectional structures of each mode, our group has proposed an advanced analyzing technique, which applies poloidal mode decomposition before calculating the cross correlation. To evaluate the feasibility of this technique, slow wave and fast wave in solitary mode [6] were analyzed. Figure 1 (a) shows the cross-sectional structure of the 10.0 kHz component calculated in the conventional way. Figure 1 (b) and (c) are those of nearly 10 kHz component calculated after extracting poloidal mode number m = 8 and m = 4, respectively. It can be clearly seen that (a) is the mixture of (b) slow wave and (c) fast wave, and slow wave and fast wave are successfully distinguished by this technique.

References

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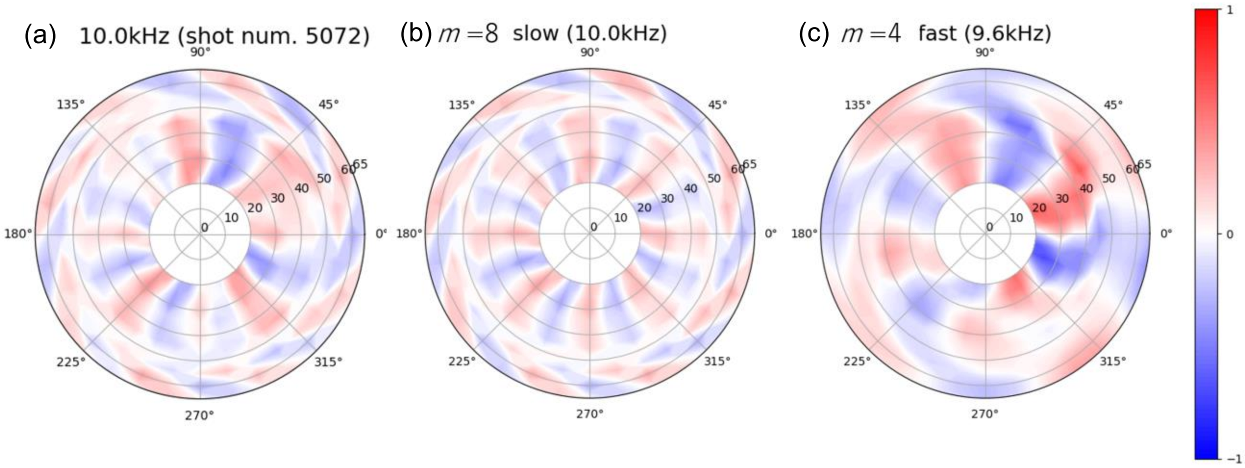

Figure 1. Real part of the cross correlation between the 64-channel poloidal probe and 10-channel radial probe arrays. (a) Frequency f = 10.0 kHz, (b) f = 10.0 kHz and m = 8, and (c) f = 9.6 kHz and m = 4 are chosen.